Tungsten isotopes and the origin of the Moon

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Lunar whole-rock samples exhibit elevated $^{182}W/^{184}W$ resulting from cosmic ray-induced neutron capture on ^{181}Ta [1]. In contrast, lunar metal samples contain no Ta and hence no cosmogenic ^{182}W, but may show apparent ^{182}W deficits due to neutron capture on W isotopes themselves [2]. Determining the indigenous $^{182}W/^{184}W$ of the Moon, therefore, requires the quantification of neutron fluences in the investigated samples. We have recently shown that Hf isotopes constitute a powerful neutron dosimeter and identified several lunar samples devoid of resolvable neutron capture effects [3]. These samples exhibit small but resolvable ^{182}W excesses of 10-20 ppm, which we interpret to reflect the $^{182}W/^{184}W$ of the Moon. The small ^{182}W excess of the Moon is in good agreement with elevated $^{182}W/^{184}W$ in some Archean samples [4], suggesting that the Moon exhibits the same $^{182}W/^{184}W$ as the BSE prior to addition of the late veneer. This observation is most easily accounted for if the Moon formed 'late' (*i.e.*, more than 50 Ma after solar system formation) and predominantly consists of terrestrial mantle material. The latter is consistent with the indistinguishable O and Ti isotope compositions of the Earth and Moon [5].

References: [1] Leya et al. (2000) *EPSL* 175. [2] Touboul et al. (2007) *Nature* 450; Kleine et al. (2005) *Science* 310. [3] Sprung et al. (2013) *EPSL* 380. [4] Willbold et al. (2011) *Nature* 477. [5] Wiechert et al. (2001) *Science* 294. Zhang et al. (2012) *Nature Geosci*. 5.